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# Developing a template for optimizing return on investment in product and process innovation

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## KEYWORDS:

Creativity, product innovation, process innovation, policy, strategy, tactics, concurrent design, concurrent product development, concurrent engineering

## ABSTRACT

Large organizations have the human, material and financial resources to undertake new product development (NPD) and innovation on a continuous basis. Skills, knowledge, technology and know-how can be purchased as required. Risks can be assessed on an on-going basis using (generally) the business approach to new product development. Small to medium sized enterprises face different challenges in new product development and innovation. Lacking the resources of the large corporations they need to be clever, selective and agile when allocating resources to NPD and innovation if they are to survive, grow and prosper in an increasingly competitive and global market.

This paper provides an account of approaches and tactics currently employed by the author to assess competitiveness; it shows how plans are formulated to improve company competitiveness and how these plans are implemented.

## INTRODUCTION

The world is in recession, well most of it. It is more accurate to say that one sixth of the world is in recession and the other five sixths is not. That part of the world in recession is the rich part, the part that for the past century or more has exploited the world's resources for personal gain. However the predicament the rich world finds itself in is nothing new, recessions in the industrialized world are cyclic, as predicted by the likes of Schumpeter (1983-1950) and Kondratieff (1892-1938). The economic cycle is perhaps best explained by the Kondratieff theory. In Phase 1 growth comes out of the depressed economy; within this phase people are prudent, they save and plan for the future through investment in new product and associated manufacturing process. In Phase 2 the limits of growth within the economy are reached and consolidation takes place. In Phase 3 there is a desire for continued growth and consumption increases causing an increase in prices and an apparent increase in wealth, but this growth is fuelled by debt as the lessons of the past are forgotten. In Phase 4 the price structure collapses and the economy goes into a period of sharp entrenchment, in effect this is a period of readjustment in the economy in preparation for the beginning of the next cycle. The whole cycle takes

around 60 years. The phase 4 is calculated by Kondratieff to last around 18 years, a three-year period over which the economy collapses followed by a fifteen-year period of readjustment before there is once more growth.

The above is a general observation of the economic plight of most of the industrialized nations. The emerging nations such as India and China did not suffer recession, their growth simply stalled until growth in their internal economies took up the slack caused by the reduction in demand of the advanced economies (Coates et al 2009).

If the Kondratieff theory is to be accepted, then the industrialized economies could be in for another fifteen years of stagnation, what is certain is that when the world recession comes to an end there will be a new world order (McKeag 2009), and those nations that have managed their economy better prior to and during the recession will be the winners.

## I. THE WAY FORWARD

The introduction gives a view on the state of the economy in many of our industrialized nations and the reasons behind it. The wealth of an economy is dependant on its ability to trade profitably, and to do so it has to produce products others want to buy. When discussing the trade imbalance between the USA and Japan some years ago (Roy et al 1990), Akio Morita, in his role as Chairman of Sony said "There are few things in the US Japanese want to buy, but there are lots of things in Japan that Americans want to buy". In the same conversation with an American money-trader, Akio asked, "How far ahead do you plan?" The answer was 10 minutes. He replied, "A 10 minute profit cycle economy does not permit companies to invest in long term development...We in Japan plan and develop our business strategies 10 years ahead." Herein perhaps lie the answer to the woes of the industrial nations, and the answer to those woes. Certainly in the UK Thatcherism decided we could abandon manufacturing industry and promote the service sector. "The City" (banking and finance) became the dominant influential force in the British economy and politics. Even when a Labor government came to power in 1997, it basically followed the monetarist policies of the preceding Conservative Government (O'Farrell, 2009). The growth in prices (property in particular) and the dependence on debt, as predicted by Kondratieff, led to the economic implosion. The broken economies of the industrialized nations now need

long-term strategies to extricate themselves from their present dilemma.

Although there is no research known to the author to substantiate this next point, it is suggested that economies need to be balanced, and the service sector (including banking and finance) should be sufficiently large, and managed in such a way as to support the wealth generating sectors of the economy they service. A case in point is the Chinese economy, which is now the world's third largest economy based primarily on manufacture and trade in manufactured goods, now has the world's third largest stock exchange.

The preceding points on the economy are to put into context the environment within which business needs to develop and grow in the coming ten to fifteen years. All economies are based on a mix of businesses, but the predominant business units are Small and Medium Size Enterprises (SME's) and it is from these that most economies see the future growth, job and wealth creation opportunities (Sherman, 2010).

National economies need exports to offset the downturn in the internal economy and to generate foreign currency. This means they need to be producing goods and to a much lesser extent services others wish to buy. But what should the businesses be based on? It can be argued that there are four ways of creating wealth, hunting, mineral resources, agriculture and manufacture. A small economy like that in Iceland can survive on hunting fish (or could before they believed the future lay in banking and finance). An economy like that in Australia can largely survive and prosper based on extracting and selling its natural resources such as coal and iron ore. The New Zealand economy could be primarily based on agriculture and secondary processing of agricultural prime produce into high added value food products. There is clear evidence of significant and sustainable increases in the world prices of prime agricultural produce such as grain (USAID, 2005) and meat (Innovation Measurement, 2008), driven by the demand of the (industrial) developing nations such as China and India. People in the growing economies, with their newfound wealth, are purchasing goods within world market and are competing for it on price; the competition is driving up prices to the benefit of the producer nations. There is every reason to believe that in the medium to long term the trend in price inflation of agricultural produce, both primary and secondary, will continue. However for industrialized nations with a high population density, and a high population in relation to natural resources, the primary means of creating wealth will be trade in manufactured goods. Secondary processing of prime agricultural produce is manufacturing, as is secondary processing of mineral resources and fish, so the trend should be for all nations to grow their manufacturing base as a means of generating wealth. To take up Akio Morita's point when discussing trade between Japan and USA, it is the responsibility of each nation to produce goods that people in other nations want to buy, if individually each is to generate wealth and prosper, such is the nature of international trade. It follows that the ability of nations to trade profitable is dependant on the collective ability of manufacturers within

its national boundaries to produce goods those in other nations wish to buy.

## II. INNOVATION, THE BASIS OF SUSTAINABLE WEALTH GENERATION

### A. *The economic argument for innovation*

The basis of economic growth has been shown to depend on five factors:

1. Additional labour
2. Improved quality of labour through education, training and experience
3. Added capital through investment
4. The rate of productivity of capital
5. Real Cost Reduction (for example through technical change, change in total factory productivity)

Additional labor means output is proportional to the labor employed. Education and training will improve the quality and productivity of labor through enhanced knowledge and understanding, in particular as it relates to cognitive, technical and physical skills. Adding to capital stock through investment, like adding to the labor force, increases output in proportion to the added capital. To achieve a high real rate of economic return as result of capital investment means that capital must have been invested in something different or differently from what went before. Finally generating real cost reductions means doing things differently.

As a general rule, once efficiencies and productivity improvements have been achieved, there is little else that can be achieved to improve the finances of a company and by implication the economy of a country. However growth in GDP is statistically better than economic theories can predict (Innovation measurement, 2008). This "unexplained" growth has relatively recently been identified for what it really is, innovation, and the growth is not steady state. The economy of a country is the sum total of the economic well being of all the businesses that make up that economy. Within each entity in the economy there is not steady state improvement across all businesses, rather "churning" is taking place whereby new businesses are formed, some improve, some decline and others disappear. The successful economies are those where the quality of labor continues to improve, and where innovation statistically flourishes (Federal Reserve Bank of Dallas, 2010).

### B. *An approach for planning SME business around innovation*

As a result of over 30 years research, design, development and innovation experience working predominantly with SME's, an approach evolved for embedding innovation in SME's. This approach was embedded within an engineering SME with very positive results (McKeag and McKnight, 2010). The approach is based on defining company policy, developing strategy (or strategies) in support of company policy, and developing a product (process and/or system) plan in support of the strategic plan(s). It can be summarized as follows:

- 1) Company Policy: this should be based on innovation and redefined along the following lines:

- a) Continuous innovation in all products, services and systems
- b) Continuous improvement in product quality and all company business operations
- c) Continuous improvement in knowledge and skills through on-going staff and personal development
- 2) Company Strategy: This should be defined and developed, Freeman's categories (Freeman, 1982) is a good comprehensive starting point:
  - a) Offensive: Designed to achieve technical and market leadership
  - b) Defensive: Being a good "second" and letting the offensive strategy based companies make the mistakes
  - c) Imitative: Competing in mature markets with "cloned" products
  - d) Dependent: Generally within a supply chain
  - e) Traditional: Based on the supply of "mature" and "ageing" products for which there continues to be a market
  - f) Opportunist: Respond to an opportunity based on the manufacturing capability of the company, perhaps supply of a niche market product not necessarily in the producers line of business
- 3) Product Plan: This should be formulated using the following guidelines:
  - a) Relatively high technology in product or process
  - b) Own brand products with high relative advantage
  - c) Standard product range if high in exports
  - d) Customized products if high in home sales
  - e) Continuous incremental product development
  - f) Excellent sales organization
  - g) Own channels of distribution and control of channels of distribution

The Booz, Allen and Hamilton product categories (Booz et al, 1982), converted into innovation format (Table 1), have been found to be a good guide in helping to identify the type of innovation required and where it fits into overall company strategy and policy. Product strategy should inform both strategic planning and policy making, and this should be an evolving scenario.

Booze, Allen and Hamilton Product Category	Corresponding Innovation Category
New-to-the-world products	Radical innovation
New product lines	Company innovation
Additions to existing lines	Evolutionary innovation
Improvements and revisions to existing products	Incremental innovation
Repositionings	Marketing innovation
Cost reductions	Organizational innovation

Table 1: Booz, Allen & Hamilton product categories translated into corresponding innovation categories

This approach is being developed and is evolving to meet the needs of SME's in many manufacturing sectors. The work in embedding this type of approach in SME's is current and will no doubt be reported on some time in the future.

#### *C. Identifying opportunities for innovation using creativity*

In recent years a three-pronged approach has been developed to support SME's implement innovation throughout their organizations, and the approach is under evolutionary development. The three stages of the approach can be explained as follows:

- 1) Taking the approach outlined in McKeag and McKnight and as summarized in section IIB above, a one-day policy/strategy session is conducted with the directors, senior management and decision makers from the company, and possibly including representatives of sub-contractors and suppliers; this group is normally referred to as "The Policy Group". The purpose is to:
  - a) Critically examine company policy and redefine it based on their actual and anticipated business
  - b) Identify a company strategy or combination of strategies that could make them more competitive in their market
  - c) Get the policy group to identify relative strengths and weaknesses of the company with regard to innovation, identify the innovation effort required across the company, and what the balance of effort (and investment) should be between categories.
- 2) Hold a one-day session based on design creativity approaches and techniques, which can vary but the following sequence has been found to generate good original results:
  - a) Have the policy group analyze a past company innovation using "The Process of Invention" (Usher, 1954), sometimes known as The Creative Process, and in particular determine the characteristics of the key people behind the innovation.
  - b) Get members of the policy group to identify innovation opportunities for solving problems known to them and using the initial stages of "The Design Process"(BS7000, 1989), one objective being to identify creative design methods they are already using intuitively.
  - c) The next exercise helps the policy group identify "Associative Thinking Techniques" they are already using intuitively, and using the techniques to help generate ideas for solving a problem identified in 2b.
  - d) Finally the technique known as "User Trip" is explained, and each individual is given the task of planning a user trip based on their role within the business, or the role of their product(s) in society. They have to undertake the user trip before the next meeting, and prepare a report on opportunities identified for presentation to the rest of the group.
- 3) The third phase is a one-day session based on use of creativity techniques to help the policy group identify ideas for commercially exploiting the innovation opportunities identified in phase 2, and in keeping with policy and strategy as identified in phase 1. The ideas are written on Post-It's, analyzed and categorized. A "mind map" based on ideas generated by the group is produced. Group member's award "stars" to the ideas they think are the best, and the ideas are then prioritized. The ideas are analyzed on a basis of commercial viability and technical feasibility and payback,

and new product (process or system) innovation plan generated.

At the end of the three-day innovation activity (each day usually separated by a two-week gap), an SME will have generated between 30 and 50 commercially viable and technically feasible ideas. Some ideas can be implemented internally without further outside assistance. However it is generally found that for those requiring technological innovation in product and/or process, for those requiring originality and creativity in design, and for those requiring modern approaches to organization and management, on-going support from the University is required. The support is generally based on a grant aided collaborative research program, technology or knowledge transfer program. Most collaborative programs are between two and four man years duration. Each project will have defined aims and objectives.

A postgraduate is generally recruited by the University to work full time within the sponsoring company on the project. While working on the project the post graduates get one half day per week direct supervision and support from an academic supervisor and daily support from an industrial supervisor. In addition ten percent of project time is set aside for training and development to help the postgraduate deliver the project in line with objectives as agreed between the company and the University. Where projects are of four man-years duration it is common practice to recruit two postgraduates to work on different aspects of the project or two different but complementary projects.

A review of past knowledge and technology transfer programs between academic and industry was carried out earlier in 2010 by independent consultants acting on behalf of the Irish Government. The objective was to determine, in the light of the austerity measures being undertaken by the Government following the collapse in the economy, whether or not funding of such projects should continue. The report found that the payback on investment was on average fifteen to one (Verbal Report, 2010). The Government has subsequently increased investment in collaborative technology based programs between academia and industry.

#### *D. Embedding creativity and innovation in SME's*

The tactics of embedding creativity and innovation in industry requires a much more long-term approach. The exercise outlined above is valuable in that it creates the basis of plans for the way forward. Design is a plan for intervention, but it is only when intervention takes place that change occurs. In the experience of the author, such plans need to be based on a "rolling" long-term (generally five year) program, and need to be adaptable to new and emerging technology and market conditions, as well as new opportunities resulting from latent need identified as a consequence of the newfound creativity within the business.

Embedding creativity and innovation within an SME is normally based on a grant aided technology transfer program, with further supported through government training and research grants mainly to the company. The technology transfer program is inevitably based on an identified company need to improve competitiveness. This may be a new technology in product or process, a need to improve

price competitiveness, a new product opportunity or an identified latent need in the market requiring original and creative thinking. Whatever the basis of the project, tactically planning incorporates a number of generic requirements:

- a) Preparation of a work-plan that will see the project become commercial reality
- b) Identify the type of the manpower resources required for the project, the mismatch between current workforce skills and those required, and incorporate a (re) training program into the work-plan.
- c) Identify new materials and production technology required and make plans to have these embedded within the company at the appropriate time.
- d) Based on the need for creativity and innovation to be embedded within the company, identify the most appropriate organizational structure to facilitate the new company policy and strategy.
- e) Put in place financial plans to pay for the resources needed for all other plans.
- f) Put in place management plans to ensure the company remains focused on its business, and the strategic and tactical plans in place are implemented

This phase comprising policy definition, strategic planning and product planning is the strategy phase. The second or tactical phase is where change actually takes place.

### III. REFLECTING ON EXPERIENCE

University/industry collaboration on innovation should not be viewed as consultancy. Consultancy generally involves "experts" being brought in to solve a problem but their expertise departs with them. In technology transfer initiatives between university and industry, the expertise of academia is embedded within the company, so competitiveness is improved. However it is not one-way traffic, too many academics work from textbooks and have little first hand knowledge or understanding of private sector industry. The collaboration enables academics to keep abreast of developments in the real world and ensure the training, education and research they provide is relevant to the needs of their community.

It is an observation that textbook approaches to innovation do not work except in the specific conditions under which they were prescribed or identified. Good approaches to innovation learn from the past, assess the present, look to the future, and on a basis of creativity in the context of innovation, design for the future.

In technology transfer programs, the "agent of change" or "facilitator" is predominantly the postgraduate recruited onto the program as a full time university employee. In 75% of cases the postgraduate, at the end of the program, is recruited onto full time company staff, thereby the expertise developed in that individual is retained and continuity of the aims and objectives of the program maintained.

Most projects are based on cost reduction or new product programs or both. This is in keeping with observations made many years ago when working with rival automotive multinationals on technology transfer programs (Headings,

1982). All new projects were referred to as “cost saving proposals” and fitted into one of three categories:

- New product programs
- Engineering change
- Reduce manufacturing costs

In today’s world the more correct terminology would be “improving competitiveness” or “continuous improvement programs”, however the three categories of competitiveness improvement or continuous improvement are still relevant. The New Product Programs and Engineering Change categories are fairly self-explanatory. The “Reduce Manufacturing Costs” category is perhaps less self-explanatory but for most companies it is the area where competitiveness can be improved throughout the business.

Experience demonstrates that most companies are open to new product programs and introduction of engineering (technology) change. However, from a cultural perspective, the area of cost reduction is the most difficult to address because it means change in organizational structure, methods of working and skills. In the context of UK and Irish companies, it has been calculated that on a basis of prime costs, industry is competitive with the best in the world. However where companies loose out is in the area of indirect (labor) costs. Best practice puts indirect costs as 30% of prime costs, however in the authors experience the norm in the British Isles is around 80%. In effect too many people are employed undertaking unnecessary non added value tasks. This is a reflection of bureaucracy (generally under the guise of management and administration) in industry. In the last century the entrepreneurial (by implication innovation) function was seen as unnecessary and in its stead arose the professional and managerial class (Schramm, 2006). In his paper Schramm goes on to state that “Bureaucracy is, in its essence, a means of communication whose purpose is to reduce risk” and “The wrenching reform of American manufacturing led to what we now recognize as non-hierarchical or “flat” organizations”.

The points made by Schramm are in keeping with observations made by the author in working with SME’s over many years. The least innovative companies tend to be those with a “rigid” hierarchical structure and “box-ticking” bureaucracy. Innovation requires people to know and understand rules and the reasons for them, and to be trained and developed so they know when to break the rules, take risks and embrace failure (Ford, 2009; Purves, 2008). In effect innovation is counter cultural to bureaucracy.

The best technique for identification of non added value tasks and identification of other waste is Value Stream Mapping (Rother et al, 1999). Basically the technique requires that all actions in the current product lines be reproduced on a “current state map” together with the information flow. The current state map is analyzed and an idealized “future state map” of the product lines and associated information flow is produced. The opportunities for improvement are identified and, generally based on a Pareto analysis, prioritized and tackled using Kaizen techniques; the aim is to remove all non added value tasks and activities from the organization in terms of product flow and information flow. The technique gives clarity to the

organization, costs are reduced and quality improved. In particular, information flow that has no bearing on product is identified and eliminated together with associated tasks. Everyone gets the correct information in robust format, those directly involved with product flow are empowered to take action; productivity and efficiency are improved.

Many SME’s have an authoritarian leadership that translates into a functional hierarchical structure. This is generally brought about because most SME’s are family owned; the business is based on the idea of a founder who was an entrepreneur. Particularly when the business is passed to the second generation the entrepreneurial spirit has disappeared, and a hierarchical organizational structure is in place; bureaucracy thrives at the expense of innovation. In this scenario SME’s have lost their main strategic weapon, the ability to be agile and responsive to new market conditions. The best organizational structure for SME’s to adopt with the objective of fostering creativity and innovation is a loose matrix structure. In this organizational structure project responsibilities are intertwined with functional business responsibilities. Employees can give more or less time to projects running in parallel with their day-to-day responsibilities, depending on the phase the project is in, and their contribution to the project at that time. The project still needs to be managed, usually by the policy management group within the company (McKeag and Clarke, 1989).

Parallel working is considered an essential element in project management if projects are to be completed on time, to budget and to specification. Parallel working is particularly useful as a means of reducing lead time to market, but it also reinforces the need for communication, multidisciplinary team-working, and significantly reduces errors. It ensures that the views of all contributors to the program are taken on board at the earliest possible time, a comprehensive and agreed program specification is generated, resulting in fewer expensive and enforced changes downstream.

Parallel working usually comes under the generic headings of Concurrent Engineering or Simultaneous Engineering. These headings are however misleading. It is observed there are three generic types of project organization based on what the author regards as Concurrent Engineering, Concurrent Product Development and Concurrent design.

Concurrent engineering is the term best used to explain the organization of one-off construction projects, such as bridge building and shipbuilding, where the architectural arrangement of modules is similar across new products but the design of the modules varies. In concurrent engineering the concept and layout design is decided at an early stage, and thereafter design and manufacture of the modules that make up the layout or architecture of the final design can continue in parallel.

Concurrent design can best describe the design and manufacture of (usually complex) products that are manufactured in volume, automobile design and manufacture is an appropriate example of concurrent design. As is the case for concurrent engineering, after the concept and layout are decided, the design of individual modules that make the

final assembly proceeds in parallel. However unlike concurrent engineering, the design of all components, sub-assemblies and proprietary items is fixed before production begins. Thereafter there is a design freeze until at some future date the model is revised or dropped from the range.

Concurrent product development describes significant projects, generally of long-term duration, where modifications and design updates can be introduced while the product is in production. Aircraft design and manufacture is an example of concurrent product development. The life expectancy of an aircraft in production is generally at least 20 years. Throughout this time many modifications will be introduced, perhaps in response to new legislation, availability of new technology, changing market and simply the desire to improve the product. These changes are introduced to aircraft on the production line as they become available. In this scenario trace ability is of utmost importance since it is necessary to know the precise configuration of every aircraft. It is estimated that after 20 years since launch of a new aircraft, there is only 40% commonality between current production models and the original aircraft.

#### IV. CONCLUSIONS

Based on the arguments put forward in this paper, it is likely that the industrialized nations of the world will suffer another 10 years of recession before there is a return to real growth and prosperity. Industrialized nations primarily generate their wealth through trade in manufactured products, and to trade successfully the industries in each trading nation must produce goods people in other countries want to buy. In most countries the manufacturing sector is primarily based on SME's, so the future wealth generation capability of each nation depends primarily on the SME sector.

Real growth and prosperity depends on the education, training and skills of the labor force, and these qualities in the labor force need to be aligned to the needs of industry. The bureaucracy of unnecessary administration and management, largely introduced in the last century, should to be removed from businesses thereby making them more cost effective and price competitive. Empowerment will ensure those with the knowledge make the decisions.

The successful trading nations invest in innovation so it is necessary to develop and embed an innovation culture in the SME's. This can be achieved at strategic and tactical level through collaboration between the third level education sector and individual SME's. To be successful there is a need for creativity and innovation to be embedded across all business operations, with integration of strategic planning, tactical planning and operations.

In addition to being innovative, SME's need to be flexible and agile so they can respond to new market opportunities, brought about for example through availability of new technology or identification of latent market need. The best way to achieve flexibility and agility is through operations based on a loose matrix structure, with projects facilitated by parallel working based on concurrent engineering, concurrent

design or concurrent product development principles as appropriate.

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